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Repeated Auctions of Incentive Contracts,
Investment and Bidding Parity
With an Application to Takeovers

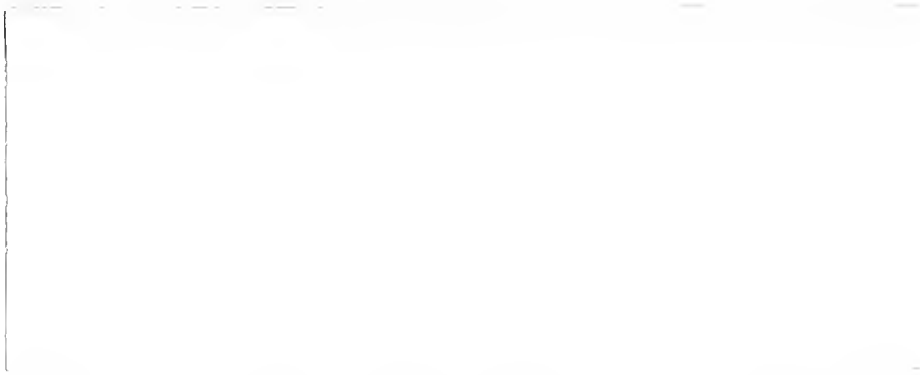
by
J.-J. Laffont and J. Tirole

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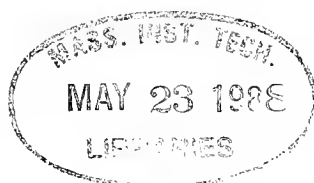
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REPEATED AUCTIONS OF INCENTIVE CONTRACTS,
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AND
BIDDING PARITY
With an Application to Takeovers*

by

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and

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May 1987

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Abstract

This paper considers a two-period model of repeated franchise bidding or second sourcing. A regulator contracts with a single firm in each period, presumably because of increasing returns to scale. The incumbent firm invests in the first period. The investment may be transferable to a second source or not; and may be monetary or in human capital. Each firm has private information about its intrinsic efficiency, and, if it is selected to produce, about the cost-reducing effort it exerts and the investment it makes. The regulator, however, observes the firm's realized cost at the end of the period (the cost includes monetary investments and may be random). In the second period the incumbent firm can be replaced by an entrant. The regulator commits to an optimal breakout rule.

The paper generalizes an earlier result that the optimal policy is to regulate through contracts linear in cost overruns. It also derives conclusions concerning the intertemporal evolution of incentive schemes. Mainly, it puts emphasis on the issue of bidding parity. It shows that three basic effects guide the optimal bias in the second-period auctioning process and determines whether the incumbent should be favored depending on the nature of investments. The outcome of the analysis is a relatively pessimistic assessment of the desirability of second sourcing when sizeable investments are at stake.

Last we reinterpret the second source as a raider, and the breakout as a takeover. We discuss the desirability of defensive tactics, and obtain some relationships between the size of managerial stock options, the amount of defensive tactics, the firm's performance and the probability of a takeover.

I INTRODUCTION

The regulation of a natural monopoly is often a repeated matter. The dynamic aspects of regulation pose specific organizational difficulties. The first difficulty, ignored in this paper, is associated with limited commitment, which can have three causes : future contingencies may be hard to foresee or to write into the contract (incomplete contract) ; the parties may be unable to commit not to renegotiate, i.e. not to sign a new mutually advantageous contract; and (in the context of regulation and planning) a regulator or a planner may not be able to bind the current and especially future administrations not to renege on the initial contract. A particularly acute issue with non-commitment is the ratcheting effect, which reflects the regulated firms' fear of facing demanding incentive schemes tomorrow if they prove efficient today; this ratchet effect considerably reduces the efficacy of high powered incentive schemes i.e., schemes that leave a large fraction of cost savings to the firm (Laffont-Tirole (1985)).

The second difficulty consists in determining the optimal breakout rule. If the regulated monopoly 's performance is not adequate, it may be in the regulator's interest to look for another firm (or team of managers) to replace the incumbent. Second sourcing indeed occurs in the reprocurement of defense contracts, or in the repeated bidding of franchises or in private contracting. Should auctions be set up, that sequentially pick the regulated firm? Should such auctions be concerned with bidding parity between the incumbent and the entrants? What is the incumbent firm's incentive to invest in physical capital? In human capital? The determination of the optimal breakout policy is the topic of this paper.

The "Chicago approach" to regulating a natural monopoly (Demsetz (1968)),

Stigler (1968), Posner (1972)) suggests that a monopoly franchise be awarded to the firm that offers to supply the product on the best terms. Franchise bidding may also be repeated over time to adjust for new, non-contracted for circumstances or to encourage entry of another, more efficient firm. Williamson (1976) ¹, responding to this approach, has forcefully made the following points.

1) Physical capital, and even more human capital, are not always easily transferable from one firm to the other. Hence symmetry between the firms is unusual at the franchise renewal stage. The incumbent enjoys an advantage over its competitors ².

2) Even when the incumbent's capital is transferable, the corresponding investment is hard to measure (accounting records can be distorted ; the quality of past investment choices admits no monetary measure ; the incumbent can integrate into supply or arrange kickbacks from the equipment suppliers ; depreciation charges are ambiguous). The prospect of possibly being replaced by an entrant lowers the incumbent's incentive to invest in capital which it won't be able to transfer at the right price ³.

These two points form the building blocks of our model. We assume that part of the incumbent's investment is general (transferable) and part is specific (non-transferable) (point 1). Furthermore the regulator can observe the regulated firm's cost (or profit), but is unable to recover the precise amount of investment from this aggregate accounting data (point 2).

The model has two periods. In the first, the regulator offers an incentive contract to a single firm (the incumbent). The incumbent's cost (which is the only variable observed by the regulator) is a function of the firm's intrinsic productivity or efficiency (β), the firm's first period "effort" (e_1) and its investment. The firm knows its productivity and chooses both

effort and investment. In the second period (reprocurement stage), the regulator can keep the incumbent or invite another firm (the entrant) to replace the incumbent. The entrant's intrinsic productivity (β') is known to the entrant only and can be higher or lower than the incumbent's. The second-period cost of the selected firm depends on its productivity, its second-period effort and on first-period investment (general for the entrant, specific and general for the incumbent). As we will show, random shocks in cost can be added without any change in our results.

Besides general and specific investments, we also distinguish investments depending on whether they are monetary or non-monetary, i.e., on whether they appear in the first period accounting data or they represent an effort cost to the managers:

a) *Monetary investment:* In this case, we assume a simple cost technology: $C_1 = \beta - e_1 + (i^2/2)$ for the incumbent in the first period, $C_2 = \beta - e_2 - \alpha i$ for the incumbent in the second period (no breakout), and $C' = \beta' - e' - \alpha k i$ for the entrant in the second period (breakout), where $0 \leq k \leq 1$. That is, a fraction k of the firm's cost savings due to investment is general and a fraction $1 - k$ is specific (not transferable). Because of investment specificity, we must carefully define bidding parity. A trivial observation is that specific investments put the entrant at a disadvantage. More interesting is the question of whether the entrant should be put at a disadvantage, given both firms' second-period efficiencies (which include the effect of investments). We say that the regulator favors the incumbent if there exists $\beta^*(\beta) < \beta - \alpha i(1 - k)$ such that the entrant is selected if and only if $\beta' \leq \beta^*(\beta)$ (Note that a full information first - or second - bid auction would yield a cutoff value $\beta^*(\beta) = \beta - \alpha i(1 - k)$). That is, the regulator may select the incumbent even though its intrinsic efficiency

(corrected for the discrepancy in specific investment) is lower than the entrant's. Similarly the regulator may favor the entrant at the reprocurement stage. We say that bidding parity obtains when the regulator favors neither the incumbent nor the entrant.

b) Non monetary investment (learning by doing): In this case we assume that rather than buying equipment (monetary investment), the managers of the firm reduce the second-period cost by raising their human capital. Their second-period human capital is related to the intensity of their first period work (for instance, the managers can exert effort that yields a device that reduces first period cost, and this device is still around at no extra cost in the second period). The specific functional form that we will be using is as follows : the incumbent's first period cost is $C_1 = \beta - e_1$. Its second period cost (in the case of no breakout) is $C_2 = \beta - e_2 - (a + b)e_1$ (where $a, b \geq 0$); the entrant's second period cost (in case of breakout) is $C' = \beta' - e' - ae_1$. That is, $a/(a + b)$ is the fraction of general human capital (transferable through transfer of personnel or compulsory exchange of information) and $b/(a + b)$ is the fraction of specific human capital. We will say that the regulator favors the incumbent if there exists $\beta^*(\beta) < \beta - be_1$ such that the entrant is selected if and only if $\beta' \leq \beta^*(\beta)$.

The distinction between the two types of investments is not semantic. Monetary investment increases the first period cost, while learning by doing investment decreases it. Not surprisingly, the policy implications will turn out to be slightly sensitive on the nature of investments.

Our paper emphasizes three themes : bidding parity (does the regulator favor or discourage entry?); possibility of second sourcing through an auction mechanism ; extent of incentives (does the incumbent face a steeper incentive scheme in the second period than the entrant? than itself in the first

period ?).

Concerning bidding parity, we will unveil three effects. Because the derivations are somewhat complex, we here take the liberty of lengthening this introduction in order to offer the heuristics behind these effects. The first two effects exist for both monetary and non-monetary investments. The third appears only in the case of a non-monetary investment.

1) Non appropriability of general investment. Note first that because of moral hazard only a fraction of the incumbent's first-period cost is reimbursed to the incumbent. Hence monetary investments, just like non-monetary ones, are costly to the incumbent. Now the incumbent is reluctant to make general investments, because it will not be the beneficiary in case of breakout (note that specific investments will also be lost in case of a breakout, but this effect is correctly internalized by the incumbent). Thus general investment creates a positive externality from the incumbent to the entrant. The way to encourage the incumbent to increase its general investment is to lower the probability of a breakout. This effect calls for favoring the incumbent in the reprocurement stage.

2) Rent differential associated with specific investment. This effect is more subtle than the first. To understand it, it is convenient to recall the static single firm regulatory problem. Let β be drawn from a cumulative distribution function $F(\cdot)$, with density $f(\cdot)$ on $[\underline{\beta}, \bar{\beta}]$. When choosing an incentive scheme for the firm, the regulator must trade off efficiency (which would call for a fixed price contract), and minimization of the firm's informational rent (which would call for a cost-plus contract). This trade off yields a distortion in the effort allocation for all $\beta > \underline{\beta}$. By reducing the distortion in effort for parameter β , the regulator realizes a gain proportional to $f(\beta)$. At the same time, it must give a higher rent to all types of

firms that are more efficient than β (in proportion $F(\beta)$), because the latter can always mimic the behavior of a less efficient firm. At the optimum, the marginal gain in efficiency must equal the marginal cost associated with the firm's expected rent. Hence the effort distortion increases with the "hazard rate" $F(\beta)/f(\beta)$. Now consider our two-period model. Suppose that the incumbent's and the entrant's productivity parameters β and β' are independently drawn from the same distribution $F(\cdot)$ (that is, we want to attribute any observable discrepancy in intrinsic efficiency to the incumbency advantage). Suppose that, in the second period, the regulator does not favor the incumbent or the entrant, and consider parameters β and β' such that the two firms have the same *second-period* intrinsic efficiency. In the presence of specific investment, $\beta' = \beta^*(\beta) < \beta$. Thus, if we make the classic assumption that the hazard rate F/f is an increasing function,⁴ one has $F(\beta^*)/f(\beta^*) < F(\beta)/f(\beta)$. This means that at equal second-period intrinsic efficiency, the optimal regulation of the entrant calls for less distortion of effort than that of the incumbent. An equivalent way of rephrasing this intuition consists in noticing that the selection of a firm amounts to an upward truncation of the distribution of its productivity parameter. Thus, at equal second-period intrinsic efficiency, the regulator is less uncertain about the entrant's productivity than about the incumbent's, and therefore can regulate the entrant more efficiently. Specific investments thus call for favoring the entrant at the reprocurement stage.

An interesting analogy with the literature can be drawn here. Demski, Sappington and Spiller (1987) offer a second sourcing example in which the purchaser selects the entrant rather than the incumbent to be the producer, even though he knows that the incumbent has lower production costs (Corollary 5, page 91. For similar results, see Caillaud [1985], and in the classic

context of auctioning of an object, Myerson [1981] and McAfee-McMillan [1984]). The Demski et al model does not have any investment. However, the incumbent's and the entrant's production costs are in this example drawn from asymmetric distributions: the incumbent's cost distribution is assumed to stochastically dominate the entrant's. Our model does presume identical cost distributions ex-ante, but the existence of specific investment confers a (statistical) superiority on the incumbent ex-post. Like Demski et al., we find that this stochastic dominance by the incumbent calls for favoring the entrant.

3) First-period incentive effect under learning by doing. Recall that the incumbent's informational rent comes from the possibility of mimicking a less efficient type's cost by exerting less effort. Under learning by doing, a reduction in the first period effort reduces the second period efficiency and rent, and this all the more if the probability of keeping the franchise is high. So, the regulator, by increasing the probability of choosing the incumbent in the second period, makes it more costly for the incumbent to hide its efficiency in the first period. This effect (which does not exist for monetary investments) calls for favoring the incumbent.

Bidding (non) parity results from these three effects. So for instance, in the absence of specific investment, the incumbent should be favored; if investment is specific and monetary, the entrant should be favored. (By contrast observable investments call for bidding parity). The concluding section discusses these effects, and gives a fairly pessimistic assessment of the desirability of second sourcing.

A second contribution of this paper is the characterization of the optimal incentive schemes under investment and second sourcing. We generalize our earlier result (Laffont-Tirole (1986))⁵ that the regulator can use a menu

of linear contracts. This property is particularly attractive under cost uncertainty. Our linear schemes are still optimal if random measurement or forecast errors are added to the functions C_1, C_2, C' (indeed they are optimal under any uncertainty about the distribution of the noise term). Linearity means that the regulator can ask the regulated firm to announce an expected cost for the period. The firm is then penalized or rewarded as a function of cost overruns. In our model, we can prove that the regulator can optimally give incentive schemes of the following form (where "a" identifies announced costs) :

$$t_1(C_1^a, C_1) = G_1(C_1^a) - K_1(C_1^a)(C_1 - C_1^a) \text{ to the incumbent in period one}$$

$$t_2(C_2^a, C_2 | C_1^a) = G_2(C_2^a, C_1^a) - K_2(C_2^a)(C_2 - C_2^a) \text{ to the incumbent in period two (in case of no breakout)}$$

$$t'(C^a, C' | C_1^a) = G(C^a, C_1^a) - K'(C^a)(C' - C^a) \text{ to the entrant in period two (in case of breakout),}$$

where t_1, t_2 and t' are the net transfers (after cost reimbursement), G_1, G_2 and G the fixed components of the transfers, and K_1, K_2 and K' the slopes of the incentive schemes (these slopes are equal to 0 for cost-plus contracts and to 1 for fixed-fee contracts).

The interesting questions refer to the slopes of the incentive schemes : how do those schemes compare to cost-plus and fixed-price contracts? Do incentives go up over time for the incumbent ($K_1 < K_2$)? Does the entrant face steeper incentives? We find that most incentive contracts are "incentive contracts", with slope between 0 and 1. An exception is the case of learning by doing for which the slope of the first period incentive scheme may exceed 1⁶. The intuition in this case is that to give incentives to invest in general

and specific learning by doing, the regulator strongly penalizes high first period costs. A second result (also a generalization of our earlier results) is that the slopes of these incentive schemes decrease with announced cost. A third result is that, under a *monetary* investment, the incumbent's incentives to exert effort grow over time ($K_1 < K_2$). The intuition is that a contract resembling more a cost plus contract in the first period is more conducive to monetary investments, while a contract closer to a fixed price contract in the second period allows the incumbent to cash the proceeds of the investment. This result is to be contrasted with the *learning by doing* case, for which, under some conditions, $K_1 > K_2$. As we observed earlier, learning by doing calls for strong cost incentives in the first period. We again observe the crucial role played by the nature of investment. Last we show that, for $\beta = \beta'$, the incumbent is given a steeper second-period incentive scheme than the entrant.

We can reinterpret our model of second sourcing as one of takeovers. The incumbent firm becomes the incumbent management team. The second source is the raider (rival management team). Cost is reinterpreted as profit. Favoring the incumbent at the contract renewal stage corresponds to allowing certain defensive tactics. Our pessimistic assessment of second sourcing translates into a qualification of the economists' recent partial view of takeovers as a managerial discipline device. We also show that, in an optimal managerial contract, the firm's performance, the manager's golden parachute and his level of stock options are positively correlated. These three variables are negatively correlated with the probability of a takeover.

Finally we should make a methodological point concerning the amount of information received by the entrant about the incumbent's productivity. The revelation principle tells us that the principal may w.l.o.g. ask the incum-

bent to truthfully announce his type: $\tilde{\beta} = \beta$. Should $\tilde{\beta}$ be revealed to the entrant? If not, the incumbent's first-period cost still reveals information about the incumbent's productivity. Is it worth distorting the first-period allocation to garble the entrant's information about β ? For instance, if the optimal first-period regulation implies that C_1 perfectly reveals β (as will be the case here), would one want to induce some first-period pooling, so that the entrant would possess less information about β than the principal and possibly would bid more aggressively? Fortunately the answer is no. Maskin and Tirole (1985), in their study of contracts designed by an informed principal, (here the regulator), show that, if preferences are *quasi-linear* (as is the case in this paper), the design of the contract for the entrant does not depend on whether the agent (here the entrant) knows the principal's information or not. Hence there is no point hiding the announcement $\tilde{\beta}$ from the entrant or distorting the first-period allocation⁷.

Before proceeding we would like to acknowledge the earlier literature on intertemporal procurement of a single firm under commitment (Baron-Besanko (1984)), second sourcing (Anton-Yao (1987), Caillaud (1985), Demski et al (1987), Scharfstein (1986)) and auctions of incentive contracts (Laffont-Tirole (1987), McAfee-McMillan (1987), Riordan-Sappington (1987)). Although none of these papers considers simultaneously intertemporal regulation, investment and second sourcing, and therefore is apt to address the issue of bidding parity, we make considerable use of their insights.

Section II describes the main characteristics of our dynamic model. The case of observable monetary investment is treated in Section III. Unobservable monetary investment is taken up in Section IV. Section V deals with learning by doing. Section VI sketches the takeover reinterpretation; and a few conclusions are gathered in Section VII.

II THE BASIC MODEL

We first consider a two-period information and investment-free model. Each period a project valued S by consumers must be realized. In period 1, there is a single firm, the incumbent, with cost function:

$$(1) \quad C_1 = \beta - e_1$$

where $\beta \in [\underline{\beta}, \bar{\beta}]$ is its intrinsic cost parameter and e_1 is the level of effort achieved by the firm's manager. The disutility of effort is $\psi(e_1)$, $\psi' > 0$, $\psi'' > 0$, $\psi''' \geq 0$.⁸

In period 2 the incumbent has a cost function:

$$(2) \quad C_2 = \beta - e_2$$

where β is the same parameter as in period 1 and e_2 is the effort exerted in period 2.

In period 2 there is a potential entrant with cost function:

$$(3) \quad C' = \beta' - e'$$

where $\beta' \in [\underline{\beta}, \bar{\beta}]$ is the entrant's intrinsic cost parameter and e' is his level of effort. The entrant has the same disutility of effort as the incumbent.

The parameters β and β' are independently drawn from the same distribution with c.d.f. $F(\beta)$ and density function $f(\beta)$ continuous and positive on $[\underline{\beta}, \bar{\beta}]$, with $d(F(\beta)/f(\beta))/d\beta \geq 0$.⁹

The regulator's problem is to organize production so as to maximize social welfare.

The expected utility level of the incumbent is:

$$(4) \quad U = t - \psi(e_1) - \delta \Pi \psi(e_2),$$

where δ is the firm's discount factor, Π is the probability that the incumbent will remain active in period 2, t is the net (i.e. in addition to realized

costs) expected transfer received by the firm from the regulator.

To obtain the incumbent's participation the regulator must ensure that:

$$(5) \quad U \geq 0,$$

where the individual rationality level has been normalized to zero (note that, because of commitment, we consider only an intertemporal individual rationality constraint. We will later show that the optimal allocation can be implemented through a second-period auction, so that one can costlessly satisfy the second-period individual rationality constraint as well).

The entrant's utility level if it is active in period 2 is :

$$(6) \quad V = t' - \psi(e'),$$

where t' is the net transfer received from the regulator. The entrant's individual rationality constraint is:

$$(7) \quad V \geq 0.$$

Under complete information it is clear that the potential entrant should be allowed to enter if and only if $\beta' < \beta$.

Let $(1 + \lambda)$ be the social opportunity cost of money. Then, the consumers' expected utility level is:

$$(8) \quad S - (1 + \lambda)(C_1 + t_1) + \delta(1 - F(\beta)) [S - (1 + \lambda)(C_2 + t_2)] \\ + \delta \int_{\underline{\beta}}^{\beta} [S - (1 + \lambda)(C'(\beta') + t'(\beta'))] f(\beta') d\beta'$$

assuming that consumers have the same discount factor as the incumbent.

An utilitarian regulator maximizes the sum of expected utilities of consumers and firms. As $\lambda > 0$, the IR constraints (5) and (6) are binding. The regulator's optimization program reduces to:

$$\begin{aligned}
 (9) \quad \text{Max}_{\{e_1, e_2, e'\}} \quad & \{S(1 + \delta) - (1 + \lambda)(\beta - e_1 + \psi(e_1)) \\
 & - \delta(1 - F(\beta))(1 + \lambda)(\beta - e_2 + \psi(e_2)) \\
 & - \delta(1 + \lambda) \int_{\underline{\beta}}^{\beta} (\beta' - e' + \psi(e')) f(\beta') d\beta'\}
 \end{aligned}$$

yielding the first order conditions:

$$(10) \quad \psi'(e_1) = \psi'(e_2) = \psi'(e') = 1$$

To sum up, the marginal disutility of each type of effort is equated to its marginal benefit, the IR constraints are binding because transfers are costly ($\lambda > 0$), and the entrant is selected if and only if $\beta' < \beta$.

Suppose now that the regulator observes cost but does not know the parameters β and β' even though it knows their distribution and that it cannot observe effort levels. As will be seen as special cases of the forthcoming section, effort levels should then be distorted but the entry rule should remain the same, the intrinsic cost parameters being elicited through a revelation mechanism. An intuitive explanation can be given as follows. With respect to the incumbent, because of perfect correlation of β across periods, the optimal dynamic revelation mechanism with commitment is the repetition of the optimal Laffont and Tirole (1986) static mechanism whatever the weight attached to period 2. As moreover the incentive problem created by the entrant is independent of the first one, there is no point in distorting the entry rule obtained under complete information. If we denote $\beta^*(\beta)$ the level of β' below which the entrant is allowed in, the breakout rule is $\beta^*(\beta) = \beta$.

We will now introduce various forms of first period investment by the incumbent which will justify an alteration of the entry rule, i.e. the unequal treatment of the incumbent and the entrant in the second period.

III OBSERVABLE MONETARY INVESTMENT

Let us assume now that the incumbent can, by investing $i^2/2$ in period 1, decrease its cost in period 2 by αi . This investment can either be non specific, i.e. decrease also by αi the cost of the entrant, or specific, i.e. decrease only its own cost. We let k denote the fraction of investment that is transferable to the entrant:

$$(11) \quad C_1 = \beta - e_1 + (i^2/2)$$

$$(12) \quad C_2 = \beta - e_2 - \alpha i$$

$$(13) \quad C' = \beta' - e' - k\alpha i$$

Under complete information, the breakout rule is

$$\beta^*(\beta) = \beta - \alpha(1-k)i,$$

i.e. the second period efficiency levels are simply compared. The regulator's optimization problem is therefore:

$$(14) \quad \begin{aligned} \text{Max} \quad & \{S(1 + \delta) - (1 + \lambda)(\beta - e_1 + (i^2/2) + v(e_1)) \\ & \{e_1, e_2, e', i\} \\ & - \delta(1 - F(\beta - \alpha(1 - k)i))(1 + \lambda)(\beta - e_2 - \alpha i + v(e_2)) \\ & - \delta(1 + \lambda) \int_{\beta}^{\beta^*(\beta)} (\beta' - e' - k\alpha i + v(e'))f(\beta')d\beta'\} \end{aligned}$$

where e_1 , e_2 and i are functions of β and e' is a function of β' .

This is a quasi concave problem¹⁰ with first order conditions:

$$(15) \quad v'(e_1) = v'(e_2) = v'(e') = 1$$

$$(16) \quad i = \delta\alpha [(1 - F(\beta - \alpha(1 - k)i)) + kF(\beta - \alpha(1 - k)i)]$$

(16) tells us that investment should be set at the level that equates its marginal cost, i , with its expected social marginal utility which is $\delta\alpha$ if the investment is non-specific ($k = 1$), but only $\delta\alpha(1 - F(\beta - \alpha i))$ if it is specific ($k = 0$). The positive externality of the first period investment on

the entrant must be internalized when it exists.

Suppose now that the investment is observable by the regulator (from accounting data), but that the regulator cannot observe effort levels and does not know the values of β and β' . However, he knows that β and β' are independently drawn in the distribution $F(\cdot)$ and he can ex post observe costs. The regulator must use incentive mechanisms to extract these pieces of information in order to organize production and compensate managers for their efforts. We assume that the regulator can commit over the two periods. From the revelation principle the optimal regulatory mechanism is identical to a revelation mechanism which specifies for the incumbent, a transfer $t(\beta)$, an investment $i(\beta)$, a cost in period 1, $C_1(\beta)$, and a cost in period 2, $C_2(\beta)$ if the first period firm is kept in period 2, and for the entrant, a transfer $t'(\beta', i)$ and a cost $C'(\beta', i)$ if the entrant is selected, i.e. if $\beta' \leq \beta^*(\beta, i)$, where t' , C' , β^* can depend on i which is observable (it is easily shown that the optimal breakout policy is a tail truncation). Despite the fact that i is a function of β , the notations $C'(\beta', i)$ and $\beta^*(\beta, i)$ and similar subsequent notations should not be confusing.

Let us first characterize the revelation mechanisms which induce truthful revelation by the incumbent.

The incumbent maximizes his expected utility with respect to his announcement $\bar{\beta}$. His expected utility is:

$$(17) \quad U(\beta, \bar{\beta}) = t(\bar{\beta}) - \psi(\beta - C_1(\bar{\beta}) + (i^2/2)) - \delta(1 - F(\beta^*(\bar{\beta}, i))) \psi(\beta - C_2(\bar{\beta}) - \alpha i).$$

Let us denote $U(\beta) = U(\beta, \beta)$, the expected utility from truthtelling. From incentive compatibility, $U(\beta)$ is non increasing in β and therefore almost everywhere differentiable. At a point of differentiability, the envelope theorem implies that:

$$(18) \quad \dot{U}(\beta) = -\psi'(\beta - c_1(\beta) + (i^2/2)) - \delta(1 - F(\beta^*(\beta, i)))\psi'(\beta - c_2(\beta) - \alpha i)$$

(where i depends on β).

Sufficient second order conditions are (see appendix 1):

$$(19) \quad \frac{dc_1}{d\beta} \geq 0; \quad \frac{dc_2}{d\beta} \geq 0; \quad \frac{d\beta^*}{d\beta} \geq 0.$$

Note that $\dot{U} < 0$ so that the IR-constraint will be binding at $\bar{\beta}$ only (as the regulator's welfare is decreasing in U -see below). Then the incumbent's IR-constraint reduces to:

$$(20) \quad U(\bar{\beta}) = 0.$$

Similarly, for any β , the potential entrant announces $\tilde{\beta}'$ to maximize:

$$(21) \quad \tilde{V}(\tilde{\beta}', \beta', i) = t'(\tilde{\beta}', i) - \psi(\beta' - c'(\tilde{\beta}', i) - \alpha ki).$$

As above, let $V(\beta', i) \equiv \tilde{V}(\beta', \beta', i)$ denote the entrant's utility level when telling the truth. From incentive compatibility and the envelope theorem we have:

$$(22) \quad \frac{\partial}{\partial \beta'} V(\beta', i) = -\psi'(\beta' - c'(\beta', i) - \alpha ki).$$

The necessary and sufficient second order condition is here:

$$(23) \quad \frac{\partial c'}{\partial \beta'}(\beta', i) \geq 0 \quad \text{for any } i.$$

As V is non increasing in β' , the entrant's IR constraint reduces to:

$$(24) \quad V(\beta^*(\beta, i), i) = 0 \quad \text{for any } \beta$$

since it is selected if and only if $\beta' < \beta^*(\beta, i)$.

Integrating (22) we derive the entrant's rent of asymmetric information

$$(25) \quad V(\beta', i) = \int_{\beta'}^{\beta^*(\beta, i)} \psi'(\tilde{\beta} - c'(\tilde{\beta}, i) - \alpha ki) d\tilde{\beta}.$$

If we neglect momentarily second-order conditions, incentive and IR constraints are summarized by (18), (20), (22), and (24): The regulator must

maximize his expected utility under those constraints. As we are using U and V as state variables we slightly rewrite the objective function of the regulator as

$$\begin{aligned}
 (26) \quad & \int_{\beta'}^{\bar{\beta}} \{ S(1 + \delta) - (1 + \lambda)(C_1(\beta) + \psi(\beta - C_1(\beta) + (i^2/2))) - \lambda U(\beta) \\
 & - (1 + \lambda)\delta(1 - F(\beta^*(\beta, i)))(C_2(\beta) + \psi(\beta - C_2(\beta) - \alpha i) \\
 & - \delta \int_{\underline{\beta}}^{\beta^*(\beta, i)} [(1 + \lambda)(C'(\beta', i) + \psi(\beta' - \alpha ki - C'(\beta', i)) \\
 & + \lambda V(\beta', i))] f(\beta') d\beta' \} f(\beta) d\beta.
 \end{aligned}$$

This optimization problem is quasi-concave (for λ small) and separable. For given β and $\beta^*(\beta, i)$, we can maximize the inside integral with respect to C' under the constraints (24) and (25).

$$(27) \quad \text{Min} \int_{\underline{\beta}}^{\beta^*(\beta, i)} [(1 + \lambda)(C'(\beta', i) + \psi(\beta' - \alpha ki - C'(\beta', i)) + \lambda V(\beta', i))] f(\beta') d\beta'$$

s.t.

$$(28) \quad \frac{\partial V}{\partial \beta'}(\beta', i) = -\psi'(\beta' - \alpha ki - C'(\beta', i))$$

$$(29) \quad V(\beta^*(\beta, i), i) = 0.$$

The first-order condition of this control problem (see Laffont-Tirole (1986)) yields effort $e'(\beta') = e^*(\beta')$, where $e^*(\beta')$ is given by:

$$(30) \quad \psi'(e^*(\beta')) = 1 - \frac{\lambda}{1 + \lambda} \frac{F(\beta')}{f(\beta')} \psi''(e^*(\beta'))$$

for any $\beta' < \beta^*(\beta, i)$. Equation (30) defines the optimal effort level and therefore the optimal C' function:

$$(31) \quad C^*(\beta', i) = \beta' - \alpha ki - e^*(\beta').$$

If he is selected ($\beta' < \beta^*(\beta, i)$), the entrant has rent:

$$(32) \quad v^*(\beta', i) = \int_{\beta'}^{\beta^*(\beta, i)} \psi'(e^*(\tilde{\beta})) d\tilde{\beta}.$$

We can now maximize (26) with respect to $C_1(\beta)$, $C_2(\beta)$, $\beta^*(\beta, i)$, i under (18) and (20). This is a quasi-concave problem for $\delta\alpha^2$ small enough.

The Hamiltonian is:

$$(33) \quad H = f(\beta) [S(1 + \delta) - (1 + \lambda)(C_1(\beta) + \psi(\beta - C_1(\beta) + (i^2/2))) - \lambda U(\beta) \\ - (1 + \lambda)\delta(1 - F(\beta^*(\beta, i)))(C_2(\beta) + \psi(\beta - C_2(\beta) - \alpha i)) \\ - \delta \int_{\underline{\beta}}^{\beta^*(\beta, i)} [(1 + \lambda)(C^*(\beta', i) + \psi(\beta' - \alpha ki - C^*(\beta', i))) + \lambda \int_{\beta'}^{\beta^*(\beta, i)} \psi'(\tilde{\beta} - \alpha ki - C^*(\tilde{\beta}, i)) d\tilde{\beta}] f(\beta') d\beta'] \\ - \mu(\beta) [\psi'(\beta - C_1(\beta) + (i^2/2)) + \delta(1 - F(\beta^*(\beta, i)))\psi'(\beta - C_2(\beta) - \alpha i)]$$

where $\mu(\beta)$ is the multiplier of the constraint (18).

From the Pontryagin principle we have:

$$(34) \quad \dot{\mu}(\beta) = - \frac{\partial H}{\partial U} = \lambda f(\beta).$$

Using the transversality condition at $\underline{\beta}$ we have:

$$(35) \quad \mu(\beta) = \lambda F(\beta).$$

Maximization with respect to C_1 , C_2 gives:

$$(36) \quad \psi'(e_2(\beta)) = 1 - \frac{\lambda}{1 + \lambda} \frac{F(\beta)}{f(\beta)} \psi''(e_2(\beta))$$

$$(37) \quad \psi'(e_1(\beta)) = 1 - \frac{\lambda}{1 + \lambda} \frac{F(\beta)}{f(\beta)} \psi''(e_1(\beta)).$$

Maximization with respect to i gives after some rearrangements:

$$(38) \quad i = \alpha\delta[1 - (1 - k)F(\beta^*(\beta, i))]$$

The marginal cost of observable investment is set equal to its expected social marginal value.

Maximization with respect to β^* gives:

$$(39) \quad \beta - \alpha_i - e_2(\beta) + \psi(e_2(\beta)) - [\beta^* - \alpha_{ki} - e'(\beta^*) + \psi(e'(\beta^*))]$$

$$= \frac{\lambda}{1+\lambda} \left[\frac{F(\beta^*)}{f(\beta^*)} \psi'(e'(\beta^*)) - \frac{F(\beta)}{f(\beta)} \psi'(e_2(\beta)) \right]$$

Note finally that under our assumptions the second-order conditions (19) and (23) are satisfied. We now draw the implications of this analysis.

Breakout rule:

Consider first the case where investment is non specific ($k=1$); both firms are exactly in the same technological situation in period 2. Moreover as seen from (30) and (36) optimal distortions of efforts in period 2 are identical. This, together with (39), implies bidding parity: $\beta^*(\beta) = \beta$.

Proposition 1: With observable and non specific monetary investment, the breakout rule is $\beta^*(\beta) = \beta$. That is, bidding parity holds.

Both firms are treated equally and investment being observable is set at its optimal level, because incentives problems do not interfere with the fact that the marginal utility of investment is always $\delta\alpha$.

Suppose now that investment is at least partly specific ($0 \leq k < 1$). The relevant notion of equal treatment is here

$$(40) \quad \beta^* = \beta - \alpha_i(1 - k)$$

because now, for the same β -value, the incumbent is more efficient. We show below that the entrant should be favored relatively to this equal treatment notion.

Proposition 2: With observable and (at least partly) specific monetary investment, the breakout rule is such that: $\beta^*(\beta, i) > \beta - \alpha i(1-k)$. That is, the entrant is favored.

Proof: There is an advantage to the entrant if $\beta^*(\beta, i) > \beta - \alpha i(1-k)$.

At $\alpha = 0$ we know that there is equal treatment. The result will follow if for any $\alpha \geq 0$

$$(41) \quad \frac{d\beta^*}{d\alpha} + \alpha(1-k) \frac{di}{d\alpha} + i(1-k) > 0.$$

(41) holds from straightforward differentiation of (39) and the use of the monotone hazard rate property and (30) and (36).

Q.E.D.

At $\beta^* = \beta - \alpha(1-k)i$, firms are technologically equivalent. However the rent obtained in period 2 depends on β for the incumbent and on $\beta^* < \beta$ for the entrant. So it is easier to give incentives to the entrant. Due to the "rent differential effect" (see introduction), the entrant should be favored.

Investment level

As i is observable, it is easy to impose the optimal investment level conditionally on the breakout. Here this results in an investment level lower than the first best level because the expected social marginal utility of i is lowered by the distortion in the breakout rule favoring the entrant.

Proposition 3: The observable investment level is lower than the first best level.

Decentralization through linear contracts

From Laffont-Tirole (1986), we know that we can rewrite the incentive

contract of the entrant as a menu of incentive schemes which are linear in the overruns:

$$(42) \quad t'(C', \beta', i) = G(\beta', i) - K(\beta')(C' - C^*(\beta'))$$

with $K(\beta') = \psi'(e^*(\beta'))$.

Denoting $C^*(\beta') = C'^a$ and remembering the second order condition $\frac{dC^*}{d\beta'} \geq 0$,

we can rewrite the transfer

$$t'(C', C'^a, i) = G(C'^a, i) - K(C'^a, ki)(C' - C'^a)$$

with $K(C'^a, ki) = \psi'(\beta' - \alpha ki - C'^a)$

$$= \psi'(\beta'^{-1}(C'^a) - \alpha ki - C'^a).$$

The second-order condition associated with the menu of linear contracts requires λ small enough.

We can now extend this reasoning to the case of the incumbent. For λ small enough the second-order conditions are satisfied and the transfer to the incumbent can be decomposed into two menus of linear incentive schemes, one for each period

$$t_1(C_1, C_1^a, i) = G_2(C_1^a, i) - K_1(C_1^a, i)(C_1 - C_1^a)$$

$$t_2(C_2, C_2^a, i) = G_2(C_2^a, i) - K_2(C_2^a, i)(C_2 - C_2^a)$$

with

$$K_1(C_1^a, i) = \psi'(e_1^*(\beta)) = \psi'(\beta^{-1}(C_1^a) + (i^2/2) - C_1^a); C_1^a = C_1^*(\beta)$$

$$K_2(C_2^a, i) = \psi'(e_2^*(\beta)) = \psi'(\beta^{-1}(C_2^a) - \alpha i - C_2^a); C_2^a = C_2^*(\beta)$$

and the decomposition between G_1 and G_2 is arbitrary with a joint constraint (only their discounted sum matters. But one can choose G_1 and G_2 so that the individual rationality constraint is binding in each period).

Lengthy computations show that for λ small enough these menus of con-

tracts induce truthtelling and right levels of effort.

From (30), (36) and (37), we see that the incumbent has incentive schemes with the same slopes in both periods and that the entrant has (for the same cost characteristic) also the same slope $\psi'(e^*(\beta))$ with $e^*(\beta)$ defined by

$$(43) \quad \psi'(e^*(\beta)) = 1 - \frac{\lambda F(\beta)}{1 + \lambda f(\beta)} \psi''(e^*(\beta)).$$

This is true when the slopes are viewed as functions of announced β parameters. However, we see from above that there are not the same functions of the announced costs.

Proposition 4: For λ small enough, the optimum can be decentralized through a menu of linear contracts. The incumbent's first - and second - period incentive schemes have the same slope: $K_1 = K_2$.

IV UNOBSERVABLE MONETARY INVESTMENT

We assume now that the investment made in period 1 is not observable by the regulator, or the entrant. Using the revelation principle, we will look at contracts $\{C_1(\beta), C_2(\beta), t(\beta)\}$ for the incumbent, $\{C'(\beta', \beta), t'(\beta', \beta)\}$ for the entrant and a breakout rule $\beta^*(\beta)$.

We should here note that we do not allow the incumbent's contract to depend on the entrant's realized cost C' following a breakout. Such a dependence might be used to alleviate the incumbent's investment incentive constraint (see below), because C' contains information about i in the case of general investment. We have shown that in the case of *specific* investment, our omission does not involve any loss of generality. It does involve a loss of generality for transferable investments. However, even for such investments, we feel that ignoring this dependence of t on C' is a good approximation of

reality. First, this dependence would create a delayed transfer or penalty. So the displaced incumbent would for instance be required to pay a penalty 5 or 10 years after the breakout which raises the issue of the feasibility of such long run contracts. Second, and maybe more importantly, the entrant's cost may be subject to manipulation. Indeed, ex-post, the entrant and the regulator have an incentive to tinker with accounting data on C' so as to force the incumbent to pay a penalty. So letting incumbent's reward depend on the entrant's cost may not be feasible after all¹¹. Third the dependence of t on C' might be sensitive to the exact distribution of noise in C' , if any. Our contracts fare well in those three respects. First, the transfers can follow production immediately. Second, the incumbent's contract does not depend on the entrant's realized cost. So this contract cannot be subject to manipulation. Third, our optimal incentive schemes can be implemented through linear contracts, and are therefore robust to any change in or any uncertainty about the distribution of forecast or accounting errors. Last, we should note that common auctions for contract renewal belong to the class of mechanisms considered here.

Because the investment is not observed by the regulator, we must add a further incentive constraint that reflects the incumbent's optimal choice of i . Because a unit increase in i requires extra effort i , with associated disutility $i\psi'(e_1)$, in the first period, and with probability $(1-F(\beta^*(\beta)))$ reduces second-period effort by α , with associated disutility $\alpha\psi'(e_2)$, this incentive constraint can be written:

$$(44) \quad -i\psi'(\beta - C_1(\beta) + (i^2/2)) + \delta\alpha(1 - F(\beta^*(\beta)))\psi'(\beta - \alpha i - C_2(\beta)) = 0^{12}$$

We use this "first-order approach" because of the concavity of the agent's program with respect to the investment choice, which holds for λ small enough. Denoting by $\nu(\beta)$ the multiplier of this constraint similar derivations as in

section III lead to the first order conditions:

$$(45) \quad \psi'(e_1(\beta)) = 1 - \frac{\lambda F(\beta)}{1+\lambda f(\beta)} \psi''(e_1(\beta)) + \frac{\nu(\beta) i}{(1+\lambda) f(\beta)} \psi''(e_1(\beta))$$

$$(46) \quad \psi'(e_2(\beta)) = 1 - \frac{\lambda F(\beta)}{1+\lambda f(\beta)} \psi''(e_2(\beta)) - \frac{\alpha \nu(\beta)}{(1+\lambda) f(\beta)} \psi''(e_2(\beta))$$

$$(47) \quad \psi'(e'(\beta')) = 1 - \frac{\lambda F(\beta')}{1+\lambda f(\beta')} \psi''(e'(\beta'))$$

$$(48) \quad [\beta - \alpha i - e_2(\beta) + \psi(e_2(\beta))] - [\beta^* - \alpha k i - e'(\beta^*) + \psi(e'(\beta^*))]$$

$$= \frac{\lambda}{1+\lambda} \left[\frac{F(\beta^*)}{f(\beta^*)} \psi'(e'(\beta^*)) - \frac{F(\beta)}{f(\beta)} \psi'(e_2(\beta)) \right]$$

$$- \frac{\nu(\beta) \alpha}{(1+\lambda) f(\beta)} \psi'(e_2(\beta))$$

$$(49) \quad 0 = -(1+\lambda) f(\beta) i \psi'(e_1(\beta)) + (1+\lambda) \delta (1 - F(\beta^*(\beta))) \alpha \psi'(e_2(\beta)) f(\beta)$$

$$- \lambda F(\beta) [i \psi''(e_1(\beta)) - \delta \alpha (1 - F(\beta^*(\beta))) \psi''(e_2(\beta))]$$

$$+ \nu(\beta) [i^2 \psi''(e_1(\beta)) + \psi'(e_1(\beta)) + \alpha^2 \delta (1 - F(\beta^*(\beta))) \psi''(e_2(\beta))]$$

$$+ f(\beta) \alpha k \delta \left[\int_{\underline{\beta}}^{\beta^*(\beta)} (1+\lambda) \psi'(e'(\beta')) f(\beta') d\beta' + \lambda \int_{\underline{\beta}}^{\beta^*(\beta)} \int_{\beta'}^{\beta^*(\beta)} \psi''(e'(\beta)) d\tilde{\beta} f(\beta') d\beta' \right].$$

Integrating the last line of (49) and using the first order condition with respect to C' we can replace this last line by: $f(\beta) \alpha \delta k F(\beta^*(\beta)) (1+\lambda)$.

Using the other first order conditions, (49) reduces to:

$$(50) \quad v(\beta) = \frac{(1+\lambda)f(\beta)[i - \alpha\delta((1 - F(\beta^*(\beta)) + kF(\beta^*(\beta)))]}{\psi'(e_1(\beta))}.$$

We first show that the following result holds:

Lemma: $v(\beta) \leq 0$ for any β .

Proof: Substitute (44) in (50). We get:

$$(51) \quad v(\beta) = \frac{(1+\lambda)f(\beta)}{[\psi'(e_1(\beta))]^2} \alpha \sigma (1 - F(\beta^*(\beta))) [\psi'(e_2(\beta)) - \psi'(e_1(\beta)) - k \frac{F(\beta^*(\beta))}{1 - F(\beta^*(\beta))} \psi'(e_1(\beta))].$$

Suppose on the contrary that $v(\beta) > 0$. From (51) and $\psi'' > 0$

$$(52) \quad e_2(\beta) > e_1(\beta).$$

From $\psi''' > 0$, we have

$$(53) \quad \psi'''(e_2(\beta)) > \psi'''(e_1(\beta)).$$

Let us now rewrite the first order conditions relative to C_1 and C_2 as follows:

$$(54) \quad \psi'(e_1(\beta)) + \frac{\lambda}{1+\lambda} \frac{F(\beta)}{f(\beta)} \psi''(e_1(\beta)) = 1 + \frac{v(\beta)i}{(1+\lambda)f(\beta)} \psi''(e_1(\beta))$$

$$(55) \quad \psi'(e_2(\beta)) + \frac{\lambda}{1+\lambda} \frac{F(\beta)}{f(\beta)} \psi''(e_2(\beta)) = 1 - \frac{v(\beta)\alpha}{(1+\lambda)f(\beta)} \psi''(e_2(\beta)).$$

Since $v(\beta) > 0$, the left hand side of (54) is larger than the left hand side of (55) implying $e_1(\beta) > e_2(\beta)$, a contradiction.

Remark: The condition $\psi''' > 0$ is actually much too strong to prove this lemma. It suffices that the expression $\psi'(e) + \frac{\lambda}{1+\lambda} \frac{F(\beta)}{f(\beta)} \psi''(e)$ be

non-decreasing in e (which is implied by either $\psi'''(e) \geq 0$ or λ small).

Equations (45) and (46) then imply that $e_1(\beta) > e_2(\beta)$, so that $\nu(\beta) \leq 0$ from (51), a contradiction.

Q.E.D.

We see from this lemma and (45) and (46) that $K_1 < K_2$ (since $\psi'(e_1(\beta)) < \psi'(e_2(\beta))$). The first period contract is closer to a cost-plus contract than the contract of the second period. Investment is encouraged if the incentive scheme is less demanding in period 1. Then in period 1 the main problem is to induce a high effort level and the contract can be made closer to a fixed price contract.

Proposition 5: With an unobservable monetary investment, the incumbent's first-period incentive scheme is low-powered relative to the second-period one: $K_1 < K_2$. Because the observable investment slope lies between K_1 and K_2 (see Proposition 4), unobservability calls for a flatter incentive scheme in the first period and a steeper incentive scheme in the second period.

When investment is non specific, the only reason of treating unequally firms in period 2 is the unobservability of i (see Proposition 1). Since the incumbent has no reason to internalize the positive externality of i , he will invest too little and should be favored to mitigate this effect.

Proposition 6: With unobservable and non specific investment ($k=1$) the breakout rule is such that $\beta^*(\beta) < \beta$. That is, the incumbent is favored.

Proof of Proposition 6:

Let $\Delta(\beta, \beta^*) \equiv (\beta^* - \alpha k i) - (\beta - \alpha i),$

$$h(\beta, e_2) \equiv \psi(e_2) - e_2 + \frac{\lambda}{1+\lambda} \frac{F(\beta)}{f(\beta)} \psi'(e_2) + \frac{\nu(\beta) \alpha}{(1+\lambda) f(\beta)} \psi'(e_2)$$

$$\text{and } g(\beta^*, e') \equiv \psi(e') - e' + \frac{\lambda}{1+\lambda} \frac{F(\beta^*)}{f(\beta^*)} \psi'(e').$$

Using (46) and (47), (48) becomes:

$$(56) \quad \Delta(\beta, \beta^*) = \max_{e_2} \{ h(\beta, e_2) \} - \max_{e'} \{ g(\beta^*, e') \}.$$

Equation (56) implies that $\Delta(\beta, \beta) < 0$, as $\nu(\beta) < 0$ implies that $h(\beta, e) < g(\beta, e)$ for all e . But the definition of Δ yields $\Delta(\beta, \beta) \geq 0$, a contradiction if

$\beta^* = \beta$ were the solution. But

$$(57) \quad \frac{\partial}{\partial \beta^*} [\Delta(\beta, \beta^*) - \max_{e_2} \{ h(\beta, e_2) \} + \max_{e'} \{ g(\beta^*, e') \}]$$

$$(58) \quad = 1 + \frac{\lambda}{1+\lambda} \psi'(e') \frac{d}{d\beta^*} \left(\frac{F(\beta^*)}{f(\beta^*)} \right) > 0$$

Hence, for (56) to be satisfied, one needs $\beta^* < \beta$, which for $k=1$ implies that the incumbent is favored.

Q.E.D.

When investment is specific, the incumbent correctly internalizes the positive effect of i . The only effect left is the rent differential effect and therefore the entrant should be favored.

Proposition 7: With unobservable and specific investment, the breakout rule satisfies $\beta^*(\beta) > \beta - \alpha i$. That is, the entrant is favored. Furthermore, the unobservability of investment imposes no cost on the regulator.

Proof of Proposition 7: Clearly the regulation can do no better when investment is unobservable than when it is observable. Let us show that he can do as well. For simplicity, let us assume that the conditions under which Proposition 4 (decentralisation through linear contracts) holds are verified. That is, the optimum can be implemented by giving the incumbent first-and second-period linear incentive schemes which have the same slope ($K_1 = K_2$). Suppose that the firm's investment is not regulated (even if it is observable). The firm then chooses i so as to minimize its total expected cost:

$$K_1(\beta) (i^2/2) - \delta K_2(\beta) (1 - F(\beta - \alpha i^*(\beta))) \alpha i,$$

where $i^*(\beta)$ denotes the investment determined in section III. Using the fact that $K_1(\beta) = K_2(\beta)$, and the equilibrium condition $i = i^*(\beta)$, this minimization yields

$$i = \delta \alpha (1 - F(\beta - \alpha i(\beta))),$$

which is nothing but (16) for $k = 0$.

So the firm makes the "right investment" even if the latter is not regulated.

[As a way of checking our equations, the reader will note that for $k = 0$, the values $\nu(\beta) = 0$, $e_1(\beta) = e_2(\beta)$ as given by (36) and (37), and $i = \alpha \delta (1 - F(\beta^*(\beta)))$ satisfy (44), (45), (46) and (50)].

Q.E.D.

The economic intuition is that the equality between the two slopes implies that the social planner's and the firm's preferences toward investment

are identical, unless there is an externality between the entrant and the incumbent. But no such externality exists for specific investment.

Transferable investment: the linear-quadratic case.

As will be discussed later, our main focus is the case of transferable investment ($k = 1$). We now obtain further results for this case, assuming that the disutility of effort is quadratic, and the distribution of cost parameters is uniform:

Assumption A: A1) $k = 1$

$$A2) \quad \psi(e) = e^2/2$$

A3) $F(\cdot)$ is uniform on $[0,1]$

$$A4) \quad 1 > (2\lambda)/(1 + \lambda).$$

Assumption A4 is technical (and is consistent with the second-order conditions which require that λ not be too large).

We can now state:

Proposition 8: Under assumption A,

- i) Bidding parity obtains at $\beta = \underline{\beta}$ (that is, $\beta^*(\underline{\beta}) = \underline{\beta}$).
- ii) The bias in favor of the incumbent is higher, the less efficient the incumbent (that is, $\frac{d}{d\beta}(\beta - \beta^*(\beta)) > 0$).
- iii) The incumbent exerts more effort in the second period than the type of the entrant which makes entry socially indifferent (that is, $e_2(\beta) > e'(\beta^*(\beta))$).

Proof of Proposition 8: See Appendix 3.

The intuition behind part (i) of Proposition 8 is that an incumbent with

type $\underline{\beta}$ has a zero probability of being replaced. He thus invests the socially optimal amount, and the selection rule need not be biased to encourage investment. Part ii) conveys an important intuition: An inefficient incumbent is replaced with high probability, and therefore invests little. The bidding process must then be biased considerably so as to encourage him to invest. Part iii) compares $e_2(\beta)$ and $e'(\beta^*(\beta))$. We knew that $e_2(\beta) > e'(\beta)$. However, there is a second effect, coming from the fact that $\beta^*(\beta) < \beta$ and that e' is decreasing. The two effects work in opposite directions, but the first dominates.

Proposition 8 enables us to obtain some interesting results on the second-period bidding process. Like in Laffont-Tirole [1987], one can view this bidding process as a first - or second - bid auction in which each bidder (here from each firm) bids for the right to choose from a menu of monopoly linear incentive contracts. Unlike in our earlier auction paper, the menus of contracts differ between the two competitors, because of the asymmetry of the problem. Let $U_2(\beta)$ denote the incumbent's second-period rent associated with the right to choose in his menu of contracts. Similarly, let $U'(\beta')$ denote the entrant's second-period rent. From incentive compatibility, we know that:

$$dU_2/d\beta = - \psi'(e_2(\beta))$$

and

$$dU'/d\beta' = - \psi'(e'(\beta')).$$

$U_2(\cdot)$ and $U'(\cdot)$ are thus defined up to positive constants. Although we will be mainly interested in their derivatives, we normalize these functions by imposing second-period individual rationality constraints. That is,

$$U_2(\bar{\beta}) = 0$$

and

$$U'(\beta^*(\bar{\beta})) = 0$$

[recall that the highest β' who may be allowed to produce is $\beta^*(\bar{\beta})$].

Now consider a second-period first - or second-price auction in which each firm bids for the right to choose from its menu of linear incentive schemes. For simplicity, we treat the case of a second-price auction (the first-price auction yields the same outcome from the usual equivalence theorem). Then the incumbent bids $U_2(\beta)$ and the entrant bids $U'(\beta')$. Now, in general, the equation $U_2(\beta) = U'(\beta')$ yields $\beta' \neq \beta^*(\beta)$, so that the second-price auction does not necessarily select the right firm. The auction must thus be biased. One way of doing so is to introduce a "golden parachute" or "cancellation fee" $G(\beta)$ to be paid to the incumbent if he is replaced. So, one can envision a first-period contracting process in which the incumbent chooses a first-period incentive scheme and a second-period golden parachute. The second-period allocation is determined by the above described auction.

In order for the right firm to be selected, the golden parachute must satisfy:

$$U_2(\beta) - G(\beta) = U'(\beta^*(\beta)),$$

as the incumbent shades his second-period bid by $G(\beta)$.

So

$$G(\beta) = \int_{\beta}^{\bar{\beta}} v'(e_2(x)) dx - \int_{\beta^*(\beta)}^{\beta^*(\bar{\beta})} v'(e'(x)) dx$$

or

$$G(\beta) = \int_{\beta}^{\bar{\beta}} [v'(e_2(x)) - v'(e'(\beta^*(x))) \frac{d\beta^*}{d\beta}(x)] dx.$$

We have:

Proposition 9: Under assumption A, the golden parachute is positive, and decreases with the incumbent's efficiency (that is, $G(\beta) \geq 0$, $\dot{G}(\beta) < 0$).

Proof of proposition 9: For a quadratic disutility of effort, one has:

$$G(\beta) = \int_{\beta}^{\bar{\beta}} (e_2 - e' \frac{d\beta^*}{d\beta}) dx$$

Proposition 8 (parts ii) and iii)) implies that $e_2 > e' \frac{d\beta^*}{d\beta}$.

Q.E.D.

As we mentioned earlier, the important result in Proposition 9 is that the golden parachute decreases with the firm's efficiency.

To summarize, the optimal allocation can be implemented by a second-period auction, in which each firm bids for the right to be the monopoly supplier. Efficient selection is obtained by offering in the first-period a golden parachute together with a first-period incentive scheme. The golden parachute is characterized in Proposition 9.

V LEARNING BY DOING

We assume now that the effort of the incumbent in period 1, e_1 , affects costs in period 2 through a learning by doing effect:

$$(59) \quad C_2 = \beta - e_2 - (a + b)e_1$$

be_1 is firm specific, but ae_1 is also transferred to the entrant in case of breakout, i.e.

$$(60) \quad C' = \beta' - e' - ae_1.$$

The first best breakout rule is $\beta^*(\beta) = \beta - be_1$, and we study in this section the effect of asymmetric information on the optimal breakout rule.

Under complete information the optimal effort levels would be determined by the program:

$$\begin{aligned}
 (61) \quad & \text{Max}_{\{e_1, e_2, e'\}} \{S(1 + \delta) - (1 + \lambda)(\beta - e_1 + \psi(e_1)) \\
 & - \delta(1 - F(\beta - be_1))(1 + \lambda)(\beta - e_2 - (a + b)e_1 + \psi(e_2)) \\
 & - \delta(1 + \lambda) \int_{\underline{\beta}}^{\beta - be_1} (\beta' - e' - ae_1 + \psi(e'))f(\beta')d\beta'\}
 \end{aligned}$$

with first order conditions¹³:

$$(62) \quad \psi'(e_1) = 1 + \delta a + \delta b(1 - F(\beta - be_1))$$

$$(63) \quad \psi'(e_2) = 1$$

$$(64) \quad \psi'(e') = 1.$$

In particular (62) equates the marginal disutility of effort to its total marginal social benefit, i.e., the first period benefit, 1, plus the non specific effect on second period, δa , plus the expected specific effect, $\delta b(1 - F(\beta - be_1))$.

Under incomplete information we must add the incentive constraints in the regulator's optimization program. Following the same lines of argument as in Section III we obtain, for the incumbent:

$$\begin{aligned}
 (65) \quad U(\beta) = & -\psi'(\beta - C_1(\beta)) - \delta(1 - a - b)(1 - F(\beta^*(\beta))) \\
 & \psi'((1 - a - b)\beta + (a + b)C_1(\beta) - C_2(\beta)).
 \end{aligned}$$

Sufficient second-order conditions are (see appendix 2)

$$(66) \quad \frac{dC_1}{d\beta} \geq 0; \frac{dC_2}{d\beta} \geq (a + b) \frac{dC_1}{d\beta}; \frac{d\beta^*}{d\beta} \geq 0.$$

The incumbent's individual rationality constraint reduces to:

$$(67) \quad U(\bar{\beta}) = 0$$

The entrant's incentive constraints are:

$$(68) \quad \frac{\partial}{\partial \beta'} V(\beta', \beta) = -\psi'(\beta' - a(\beta - C_1(\beta)))$$

$$(69) \quad \frac{\partial C'}{\partial \beta'}(\beta', \beta) \geq 0,$$

and the IR constraint is:

$$(70) \quad V(\beta^*(\beta), \beta) = 0.$$

The first-order conditions of the regulator's quasi-concave maximization problem are:

$$(71) \quad \psi'(e'(\beta')) = 1 - \frac{\lambda}{1+\lambda} \frac{F(\beta')}{f(\beta')} \psi''(e'(\beta'))$$

$$(72) \quad \psi'(e_1(\beta)) = 1 + \delta a + \delta b(1 - F(\beta^*(\beta))) - \frac{\lambda}{1+\lambda} \frac{F(\beta)}{f(\beta)} \psi''(e_1(\beta))$$

$$(73) \quad \psi'(e_2(\beta)) = 1 - \frac{\lambda}{1+\lambda} \frac{F(\beta)}{f(\beta)} (1 - a - b) \psi''(e_2(\beta))$$

$$(74) \quad \beta - be_1(\beta) - e_2(\beta) + \psi(e_2(\beta)) - (\beta^* - e'(\beta^*) + \psi(e'(\beta^*))) \\ = \frac{\lambda}{1+\lambda} \left[\frac{F(\beta^*)}{f(\beta^*)} \psi'(e'(\beta^*)) - (1 - a - b) \frac{F(\beta)}{f(\beta)} \psi'(e_2(\beta)) \right]$$

Equation (71) which describes the effort level of the entrant is the same as in the static one-firm problem (Laffont-Tirole (1986)), i.e. asymmetric information somewhat decreases the effort level with respect to the complete information case except at $\beta = \underline{\beta}$. Equation (72) differs from the first best equation through the term due to incomplete information $\lambda F(\beta) \psi''(e_1(\beta)) / (1 + \lambda) f(\beta)$ and possibly through the distortion of $\beta^*(\beta)$ from

$\beta - be_1$ analyzed below. More interestingly we see in (73) that the asymmetric information term is altered by the factor $1 - a - b$. Asymmetric information decreases less the effort level in period 2 than in a dynamic problem without learning, because of the intertemporal effect created by the first period effort level. The incentive problem is alleviated by the fact that the incumbent has more reasons to take a high level of effort in period 1. This is a crucial difference with the equation describing the entrant's effort level. For the same cost characteristic the incumbent is induced, at the same price for the regulator, to exert more effort than the entrant.

We now study the question of bidding parity.

Proposition 10: With unobservable and fully transferable learning by doing ($b = 0$), the breakout rule is $\beta^*(\beta) < \beta$. That is, the incumbent is favored.

Proof: At $a = 0$, $\beta^* = \beta$. Differentiating (74) and using (71) and (73) gives $d\beta^*/da < 0$ for any a , hence the result.

Q.E.D.

The incumbent should here be favored for two reasons, one because he works harder in period 2 and second to encourage him to partly internalize its positive externality on the entrant.

When learning is partly specific, the relevant comparison is with $\beta - be_1$. Now at $\beta^* = \beta - be_1$ the rent obtained by the incumbent is higher at the parity point and this calls for favoring the entrant. This effect may sometimes dominate the other two. To show this point we compute the derivative of $(\beta^* + be_1)$ with respect to b at the value $b = a = 0$ and show that this expression can be of either sign.

From (74) we have:

$$(75) \quad \left. \frac{d\beta^*}{db} \right|_{a=b=0} = \frac{-e_1 - \frac{\lambda}{1+\lambda} \frac{F(\beta)}{f(\beta)} \psi'(\beta)}{1 + \frac{\lambda}{1+\lambda} \psi'(\beta) \frac{d}{d\beta} \frac{F(\beta)}{f(\beta)}},$$

$$\text{where } \psi'(\beta) \equiv \psi'(e'(\beta)) = \psi'(e_2(\beta)) \Big|_{a=b=0},$$

$$(76) \quad \left. \frac{d(\beta^* + be_1)}{db} \right|_{a=b=0} = \frac{\frac{\lambda}{1+\lambda} \psi'(\beta) [e_1 \frac{d}{d\beta} \frac{F(\beta)}{f(\beta)} - \frac{F(\beta)}{f(\beta)}]}{1 + \frac{\lambda}{1+\lambda} \psi'(\beta) \frac{d}{d\beta} \frac{F(\beta)}{f(\beta)}}.$$

In the case of a quadratic effort function ($v(e) = e^2/2$) and a uniform distribution with $\bar{\beta} - \underline{\beta} = 1$, the sign of (76) is the same as that of

$$1 - \frac{1 + 2\lambda}{1 + \lambda} (\beta - \underline{\beta})$$

and so is positive for low values of β and negative for high values of β .

Coming now to the interpretation in terms of menu of linear contracts we see from (72) and (73) that $K_1 > K_2$ in the quadratic case. The first period contract is more high powered than the second period because it is more important to induce higher efforts in period 1. In the more general case, the rent differential effect (ψ''' evaluated at e_1 and e_2) may overcome this main effect.

Proposition 11: With unobservable learning by doing, in the quadratic case, the first period incentive scheme is steeper than the second period one: $K_1(\beta) > K_2(\beta)$ for all β .

VI AN APPLICATION TO TAKEOVERS

As mentioned in the introduction, our model of second sourcing can shed some light on the desirability of takeovers. The entrant can be reinterpreted as a raider, the incumbent as the current managerial team. The accounting cost stands for per-period performance (profit). The cost parameter (β) is a measure of the inefficiency of current management, and the effort variable (e) refers to the possibility of self-dealing management (appropriation of profits, luxurious offices, personal jets, golf playing...). The reprocurement stage can be thought of as a tender offer.¹⁴ The rigging of bidding parity in favor of the incumbent or the entrant is a rough formalization of defensive tactics and protakeover measures respectively.¹⁵

Our assumption that the incumbent's incentive scheme is not contingent on the entrant's performance translates into the assumption that the displaced managerial team does not keep substantial stock options in the firm after leaving. This latter assumption is made in most of the literature on the market for corporate control (e.g., Blair et al [1986], Grossman-Hart [1987], Harris-Raviv [1987]). Theoretical reasons can be found to motivate it. While the arguments advanced in the context of regulation (in particular the collusion argument - see section IV) fare less well in this context, it is well-known that if the managers are even slightly risk averse, the raider and displaced managers have ex-post an incentive to renegotiate former contracts and let the displaced managers resell stock options, which no longer serve an incentive purpose and create an excessive risk in the displaced managers' portfolio. At a more empirical level, this assumption also makes some sense. First, many acquired firms do not have outstanding shares after the takeover. So the incumbent managers automatically exercise their stock options. Second, even if the raider only acquires control, many managerial contracts specify

that the managers must exercise their options within 90 days if their employment is terminated (so, in the context of our model, the options are exercised well before the investment pays off). We feel that stock options encourage the incumbent managers to internalize the positive externality of observable investment on the raiders' post-takeover performance. Our point is that they very insufficiently or not at all make them internalize the effect of investments that are not observable by the market. While the process of investing per se is likely to be observed by the market, the investment expenditure may not be straightforwardly derived from accounting data (recall Williamson's argument), and the quality of the investment may be hard to assess. In a similar spirit, Ruback [1986, p.72] argues that "the management of most corporations has private information about the future prospects of the firm. This information usually includes plans, strategies, ideas, and patents that cannot be made public. Even if they are efficient, market prices cannot include the value of information that the market does not have." To the extent that plans, strategies, ideas, and patents result from investments, Ruback's argument fits with the notion that a non-negligible fraction of investments is not reflected in the market valuation of the firm.

In a recent and independent paper, Hermalin (1987) analyzes the popular argument that the takeover threat may lead to underinvestment. His model differs from ours in many respects and can be thought of as complementary. In Hermalin's model, investment pays off before the raider enters the market for corporate control (i.e., in period 1, in the context of our model). Managers may or may not have an investment opportunity (and this is not observed by other parties). Investment, if there is an opportunity, is always socially desirable. However, incumbent managers may not invest even in the presence of an opportunity. This is because the probability of success of the investment

is positively correlated with the manager's ability, and a failure signals a low ability and may encourage a takeover. Hermalin emphasizes how signaling (managerial career concerns) distorts managerial decisions (more generally than investments), that might convey information about managers. Our paper focuses on the nature and transferability of investment, as well as on the intertemporal evolution of managerial profit-sharing schemes.

Some implications of our model in the takeover context are [comments in parentheses refer to the analogous result for second sourcing]:

1. Firm performance and probability of takeover are negatively correlated [the first period cost $C_1(\beta)$ and the cut-off efficiency parameter for the entrant $\beta^*(\beta)$ are both increasing functions of β].
2. The use of defensive tactics to disadvantage the raider always benefits the firm's shareholders if the investment is transferable, but may hurt them if investment is not transferable [propositions 6, 7 and 10].
3. The managers are given linear incentive schemes, which can be interpreted as stock options [see sections III through V].
4. The incumbent manager's stock options increase over time if investment is monetary and decrease over time if investment takes the form of learning by doing [propositions 5 and 11].

Assuming that investment is transferable (as should be most of the firm's assets), we also have:

5. The manager's incentive package includes stock options and a golden parachute. The size of the golden parachute is positively related to the number of stock options [Proposition 9, plus the fact that K_1 (and K_2) are decreasing in β].
6. The size of the golden parachute is positively related to the firm's performance. [Proposition 9, plus the fact that a low β yields a low cost].

Conclusion 2 suggests that defensive tactics are not a priori harmful¹⁶, precisely when takeovers are most likely, i.e. when they involve low losses of specific managerial investment. While most of the incentive literature on the topic views takeovers as a managerial discipline device, we do feel that the popular fear of managerial myopia should not be neglected by economists. (And this feeling is reinforced by Hermalin's conceptually different argument).

Remark 1: Our results also have some implications for poison pills. A very rough description of poison pills is that they force the raider to pay an extra price to acquire the firm. In our model, a poison pill $P(\beta)$ reduces by as much the raider's bid (while a golden parachute decreased the incumbent's bid)¹⁷. In terms of managerial selection, a poison pill is like a negative golden parachute. We thus obtain:

5'. The amount of poison pills is negatively correlated with the incumbent manager's stock options.

6'. The amount of poison pills is negatively correlated with the firm's performance.

Remark 2: We should emphasize that our results are predictions for an optimal contract. Our view that the shareholders organize a bidding contest between managerial teams may be too simplistic. So caution should be exercised when applying our conclusions. But it is worth noting that Walking and Long [1986] found that managers with large stock holdings are less likely to oppose takeovers than managers with small stock holdings; and that Malatesta and Walking [1986] provided evidence that firms who adopt poison pill defenses are relatively unprofitable. Such empirical evidence is consistent with our normative analysis.

Remark 3: It is worth recalling the intuition of why the golden parachute (respectively, the poison pill) should increase (respectively,

decrease) with the manager's ability and performance. A first guess might have been that bad managers should be encouraged to leave through high golden parachutes and low poison pills. This however, is not correct, as bidding between managers already selects the best managers. Our point is that the auction should be rigged to encourage managers to invest. A (good) manager with probability .9 of keeping his job picks roughly the right amount of investment, and further incentives are not needed. A (bad) manager with probability .1 of keeping his job picks an inefficiently low investment (with probability .9, this investment goes to a rival manager). A low golden parachute or a high poison pill increase his probability of keeping his job and his incentive to invest.

Remark 4: Our paper supplies an efficiency reason for foreclosing entry. That is, a social planner, whose objective function puts equal weight on the incumbent and the entrant, biases the auctioning process against the entrant. When the principal is a private entity (as is the case for shareholders), the contract signed between the principal and the incumbent does not internalize its effect on the entrant's welfare. Aghion and Bolton [1987] have shown that the desire to extract the entrant's rent leads the two initial parties to sign a contract that favors the incumbent (induces too little "trade" between the initial vertical structure and the entrant): There is socially too much foreclosure. Note that both Aghion and Bolton's and our theories yield the same positive implication: the incumbent is favored at the repurchase stage. In our model, poison pills, for instance, have both efficiency as well as Aghion-Bolton anti-competitive motives.

VI CONCLUDING REMARKS

In this paper we bring some elements of answer in the agenda set by Williamson (1976) and the Chicago school concerning the optimal organization of franchise bidding for natural monopolies. To pursue this research it seems desirable to study various forms of non-commitment due either to incomplete contracting and renegotiation¹⁸ or to the possibility of mutually advantageous renegotiation¹⁹.

We have obtained some results concerning the bidding parity, the decentralization through linear contracts and the intertemporal incentive structure. Rather than repeating these results, it may be worth assessing the relevance of the various effects leading the regulator to rig the bidding process. Breakouts are most likely to be observed (and to be socially desirable) when the incumbent's investment is transferable to the entrant, i.e., when the entrant is not too much at a cost disadvantage. However, Propositions 6 and 10 show that the incumbent should be favored at the reprocurement stage precisely when investment is transferable. Propositions 8 and 9 furthermore show that the incumbent should be favored more, the higher the probability of a takeover. This leads us to a somewhat pessimistic assessment of the possibility of second sourcing in a natural monopoly situation involving substantial investments.

Last, we showed that a rich yet tractable model can be built that yields testable equilibrium relationships between switching incentives (like golden parachutes and poison pills), managerial incentive schemes (like cost sharing and stock options), probability of second sourcing and incumbent's performance.

Appendix 1

From Guesnerie and Laffont (1984), we know that sufficient local second order conditions are sufficient globally if the condition (CS+) is satisfied. Here (CS+) is fulfilled:

$$\frac{\partial}{\partial \beta} \left(\frac{\partial \bar{U} / \partial c_1}{\partial \bar{U} / \partial t} \right) = \psi''(e_1) > 0$$

$$\frac{\partial}{\partial \beta} \left(\frac{\partial \bar{U} / \partial c_2}{\partial \bar{U} / \partial t} \right) = \delta(1 - F(\beta^*)) \psi''(e_2) \geq 0$$

$$\frac{\partial}{\partial \beta} \left(\frac{\partial \bar{U} / \partial \beta^*}{\partial \bar{U} / \partial t} \right) = \delta f(\beta^*) \psi'(e_2) > 0.$$

The local second order conditions are obtained by signing positively

$$\frac{\partial^2 \bar{U}}{\partial \beta \partial \beta} \bigg|_{\bar{\beta} = \beta}.$$

We can take:

$$\frac{dc_1}{d\beta} \geq 0 ; \quad \frac{dc_2}{d\beta} \geq 0 ; \quad \frac{d\beta^*}{d\beta} \geq 0$$

Appendix 2

Sufficient conditions which sign $\frac{\partial^2 \bar{U}}{\partial \beta \partial \beta} \bigg|_{\beta = \beta^*}$ are:

$$\frac{dC_1}{d\beta} \geq 0 ; \quad \frac{dC_2}{d\beta} \geq (a + b) \frac{dC_2}{d\beta} ; \quad \frac{d\beta^*}{d\beta} \geq 0$$

These conditions are satisfied by the optimal contract, but the condition (CS+) is not always fulfilled. (CS+) amounts to:

$$\frac{\partial}{\partial \beta} \left(\frac{\partial \bar{U} / \partial C_1}{\partial \bar{U} / \partial t} \right) = \psi''(e_1) - \delta(1 - F(\beta^*)) (a + b) \psi''(e_2) \geq 0$$

$$\frac{\partial}{\partial \beta} \left(\frac{\partial \bar{U} / \partial C_2}{\partial \bar{U} / \partial t} \right) = \delta(1 - F(\beta^*)) \psi''(e_2) \geq 0$$

$$\frac{\partial}{\partial \beta} \left(\frac{\partial \bar{U} / \partial \beta^*}{\partial \bar{U} / \partial t} \right) = \delta f(\beta^*) (1 - a - b) \psi'(e_2) \geq 0$$

In particular for quadratic utility functions and $\delta(a + b) < 1$, the (CS+) conditions are satisfied everywhere. More generally there may be a problem with the first of these derivatives.

Appendix 3: Proof of Proposition 8

(i) At $\beta = \underline{\beta}$, the values $\beta^*(\underline{\beta}) = \underline{\beta}$, $\nu(\underline{\beta}) = 0$, $\psi'(e_1(\underline{\beta})) = \psi'(e_2(\underline{\beta})) = \psi'(e'(\underline{\beta})) = 1$ and $i = \alpha\delta$ solve the first-order conditions. (Note that this part of Proposition 8 does not rest on assumption A).

(ii) and (iii) We will assume that $\beta^*(\beta)$ and $\nu(\beta)$ are differentiable. This can be proved by using the implicit function theorem and the first-order conditions.

Let us first note that, $\frac{d\beta^*}{d\beta}(\underline{\beta}) < 1$. This is due to the fact that $\beta^*(\underline{\beta}) = \underline{\beta}$ (from part i)) and $\beta^*(\beta) < \beta$ for $\beta > \underline{\beta}$ (from Proposition 6).

Second, we know that $e' \equiv e'(\beta^*(\beta))$ is equal to $e_2 \equiv e_2(\beta)$ at $\beta = \underline{\beta}$ (from part i)). Hence, at $\underline{\beta}$, one has $e_2 > e' \frac{d\beta^*}{d\beta}$. But differentiating (48) in the linear-quadratic case, and using the first-order conditions (46) and (47) yields:

$$(A.1) \quad 1 - \frac{d\beta^*}{d\beta} = \frac{\lambda}{1+\lambda} (e' \frac{d\beta^*}{d\beta} - e_2) - \frac{\alpha e_2}{1+\lambda} \frac{d\nu}{d\beta}.$$

This implies that at $\beta = \underline{\beta}$, $d\nu/d\beta$ is negative. Now

$$\frac{d}{d\beta}(e' - e_2) = \frac{de'}{d\beta} \frac{d\beta^*}{d\beta} - \frac{de_2}{d\beta}.$$

Using (46) and (47) in the linear-quadratic case yields:

$$(A.2) \quad \frac{d}{d\beta}(e' - e_2) = \frac{\lambda}{1+\lambda} \left(1 - \frac{d\beta^*}{d\beta}\right) + \frac{\alpha}{1+\lambda} \frac{d\nu}{d\beta}$$

But (A.1) implies that, at $\beta = \underline{\beta}$,

$$1 - \frac{d\beta^*}{d\beta} < - \frac{\alpha e_2}{1+\lambda} \frac{d\nu}{d\beta}, \text{ so that}$$

$$\frac{d}{d\beta} (e' - e_2) < \frac{\alpha}{1+\lambda} \frac{d\nu}{d\beta} \left(1 - \frac{\lambda e_2}{1+\lambda}\right) < 0,$$

as $e_2(\underline{\beta}) = 1$ and $1 > (\lambda/(1+\lambda))$. So, $e' < e_2$ in a neighbourhood of $\underline{\beta}$.

Now, consider the lowest $\beta > \underline{\beta}$ such that:

$$\text{either A: } e'(\beta) \frac{d\beta^*}{d\beta}(\beta) = e_2(\beta)$$

$$\text{or B: } e'(\beta) = e_2(\beta)$$

$$\text{or C: } \frac{d\beta^*}{d\beta}(\beta) = 1.$$

Condition A cannot be satisfied strictly before B or C is, as $\frac{d\beta^*}{d\beta} < 1$ and

$e' < e_2$ in a neighborhood of $\underline{\beta}$.

Suppose that condition B is satisfied. So, at this β , $e' \frac{d\beta^*}{d\beta} \leq e_2$ and $\frac{d\beta^*}{d\beta} \leq 1$. The first inequality, together with (A.1) implies that

$$(A.3) \quad 1 - \frac{d\beta^*}{d\beta} \leq - \frac{\sigma e_2}{1+\lambda} \frac{d\nu}{d\beta},$$

so that $\frac{d\nu}{d\beta} \leq 0$. Using (A.2), and by the same reasoning as before, we obtain

$$(A.4) \quad \frac{d}{d\beta} (e' - e_2) \leq \frac{\alpha}{1+\alpha} \frac{d\nu}{d\beta} \left(1 - \frac{\lambda e_2}{1+\lambda}\right) \leq 0$$

(as $e_2(\beta) = e'(\beta^*(\beta)) < 1$, from equation (47)). So the function $e' - e_2$ cannot become positive at β , as it is negative earlier and has a negative slope.

Last, suppose condition C is satisfied. Equation (A.1) can be rewritten

as:

$$(A.5) \quad \frac{\lambda}{1+\lambda} (e' - e_2) = \frac{\sigma e_2}{1+\lambda} \frac{d\nu}{d\beta}.$$

But (46) and (47) yield:

$$(A.6) \quad e' - e_2 = \frac{\sigma}{1+\lambda} \frac{d\nu}{d\beta}.$$

It is easy to see that (A.5) and (A.6) are inconsistent unless $e_2 = \frac{\lambda}{1+\lambda}$. ²⁰

But, from (46), and the fact that $v(\beta) < 0$, $e_2 > 1 - \frac{\lambda}{1+\lambda}$. Since we assumed that $1 > 2\lambda/(1 + \lambda)$, we obtain a contradiction.

Thus, neither of the three conditions, A, B or C can obtain to the right of $\underline{\beta}$, which yields parts ii) and iii) of Proposition 8.

Q.E.D.

Footnotes

- 1) See also Joskow-Schmalensee (1983) in the context of the regulation of electric utilities.
- 2) Williamson (1976) also mentions administrative and political incumbency advantages which we will not study here.
- 3) Williamson also makes the important point that contracts are necessarily incomplete. Indeed, investment has been a major concern in the literature on the expropriation of relation-specific investment under incomplete contracting (Williamson [1975, 1985], Grossman-Hart [1986], Hart-Moore [1985]). While we also emphasize investment incentives, our paper departs from this literature in several important respects. First, it assumes away unforeseen contingencies and analyzes complete contracting. Second, the literature on incomplete contracting studies the role of ownership; we take ownership as given, and analyze switching incentives. Third, whether the parties can contract on investment does not matter in the absence of second sourcing in our model (while it does under incomplete contracting); assuming incomplete contracting away allows us to focus on the effects of second sourcing in a cleaner way.
- 4) This assumption is satisfied by most usual distributions (uniform, exponential, Pareto, logistic...)
- 5) For extensions of this result to static auctions see Laffont-Tirole (1987) and McAfee-McMillan (1987), and to more general settings see Caillaud and al. (1986), Melumad-Reichelstein (1986) and Picard (1986).
- 6) This assumes that the firm cannot conceal cost overruns. Another

potential exception is the incumbent's second period scheme under monetary investments.

- 7) It should be noted that when one of the parties' preferences is not quasi-linear, an informed principal (regulator) strictly gains by not revealing his information to the agent (entrant) at or before the contract proposal stage. That is, by pooling at the contract proposal stage, the different types of principal (referring here to the possible values of β , by abuse of terminology) can trade the slack variables corresponding to the agent's individual rationality and incentive compatibility constraints. This may introduce a tension between first period efficiency and optimal regulation of the entrant.

Also, the Maskin-Tirole result applies as long as the principal's information does not enter the agent's utility function (in particular, the agent's information can enter the principal's objective function, as is the case here).

- 8) $\psi'' \geq 0$ makes stochastic schemes non-optimal.
- 9) This assumption of monotone hazard rate property prevents bunching in the static model.
- 10) For $k=1$, the problem is always quasi-concave; for $k \neq 1$ we need $\alpha^2 \delta$ small enough.
- 11) One way of making t less manipulable is to force the incumbent to purchase and hold on to stocks of the entrant in case of breakout.

- 12) For $\alpha^2\delta$ small enough the problem of the incumbent is quasi-concave and this condition is sufficient to describe its investment behavior.
- 13) These conditions are sufficient with $b^2\delta$ small which is assumed below.
- 14) There is of course a large diversity of ways to acquire firms, from friendly mergers to proxy fights. The view that managerial teams bid against each other may be a good first approximation, and is taken, e.g. in Blair et. al (1986), Grossman-Hart (1987) and Harris-Raviv (1987). It should be noted that other reasonable descriptions of the auctioning process would yield similar results as in this paper. For instance, suppose that the raider buys up the whole firm, which then goes private. The auction is then equivalent to offering a fixed-price contract to the second source (that is, the raider is made residual claimant for the firm's second-period profit). Redoing the analysis by assuming that only a fixed-price contract can be offered to the entrant does not alter our intuitions.

Note also that our allowing discrimination among the raider's types yields the result that after a takeover, the firm goes private ($K' \approx 1$) when the raider is very efficient (β close to $\underline{\beta}$), and does not when the raider is less efficient ($K' < 1$ for higher β s).

- 15) A slight difference with our social planner formulation is that the shareholders do not care directly about the managers' welfare. But none of our qualitative results is affected by this change in the principal's objective function.
- 16) We suspect that the many shark repellants are far from being substitutes

and involve fairly different social costs. It would also be worthwhile investigating how each favors the incumbent managerial team.

17) So, in the terminology of section IV, $P(\beta)$ must satisfy:

$$U'(B^*(\beta)) - P(\beta) = U_2(\beta).$$

18) See Grossman-Hart (1986), Klein et al. (1978), Tirole 1986) and Williamson (1975) for investment concerns, and Laffont-Tirole (1985) for the ratcheting problem. In an incomplete contract setting, property rights do serve as switching incentives together with cancellation and entry fees. For instance, in defense procurement, the government sometimes owns the property rights on data and technological information and sometimes does not. Leaving the property right to the defense contractor can be viewed as a way of biasing the reprocurement stage in his favor; for the government must bargain with and pay some money (the equivalent of a cancellation fee) to the defense contractor for the right to supply the relevant information to a second source. Property rights have thus some of the features of the switching incentives considered in this paper. In a takeover context, the corporate charter may influence the easiness with which a raider can take control of the firm, through super-majority provisions and staggered board elections (in this respect, it is interesting to note that Grossman-Hart [1987] argue informally that family-run firms may sink considerable investments, and therefore may want to fight control changes through the allocation of voting rights).

19) As in Dewatripont [1986] and Hart-Tirole [1987].

20) $dv/d\beta = 0$ is impossible. It would yield $e' = e_2$ from (A.7). So condition

B would also be satisfied, which we showed to be inconsistent.

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